MSc in Computational Cognitive Neuroscience

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Investigating Visual Imagery (VI) for mobile EEG-based Brain-Computer Interface (BCI) systems

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Introduction

A classical VI-based EEG BCI system and Machine Learning would allow paralyzed patients such as those with locked-in syndrome an easier way of utilizing assistive technologies without being intrusive and potentially harmful.

Sviderskaya's study demonstrated that participants such as artists presented more complex neuro-dynamic processes while performing visual imagery tasks. This is important as experience can impact data quality, leading to better or worse performance of Machine Learning algorithms.

Echo-state-network (ESN) is a type of recurrent neural network (RNN). The main interest towards this network comes from the work of Fourati in emotion recognition and L.Suns work with unsupervised EEG feature extraction who used ESN due to its great success in time series prediction and classification.

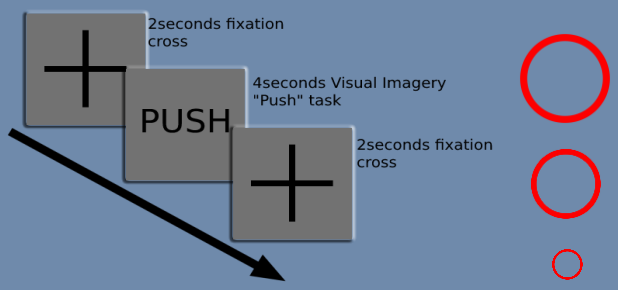
Objectives & Rationale

The rationale behind this study is to build on the relatively limited work exploring ESN as a classifier for VI-BCI. With the main research question being:

- Can ESN achieve higher efficiency in classification and prediction compared to more common approaches such as graph neural networks?

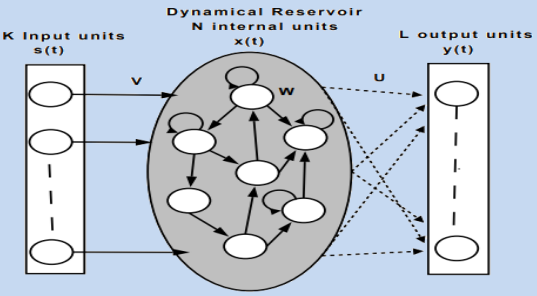
Hypothesis

We hypothesize that using a Visual Imagery based BCI and machine learning would allow us to extract and classify distinct features in raw EEG signals which would benefit the users of BrainControl.



Echo State Network (ESN)

- The ESN is a type of reservoir computer that uses a recurrent neural network with a sparsely connected hidden layer.
- The connectivity and weights of hidden neurons are fixed and randomly assigned.
- The weights of output neurons can be learned so that the network can produce or reproduce specific temporal patterns.
- Extensive use in signal processing



Design & Methods

- Participants will perform Visual Imagery tasks while wearing a portable Emotiv EpocX EEG Headset.
- The data collection paradigm consists of 100 randomly generated trials across two conditions (50 “RELAX” and 50 “PUSH” conditions).
- The cues RELAX and PUSH appear on the screen instructing participants which condition to perform.
- A fixation cross appears on the screen before and after VI task, providing us a pre-stimulus baseline.

Future Steps

- Filtering to increase signal-to-noise ratio using standard Independent Component Analysis.
- Feature extraction in the time-frequency using wavelet transform focusing between 8-30Hz.
- Offline classification using a custom-made echo-state network in python.
- Consider statistical methods such as cluster-based premutation tests to extract precise channels

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